79-1941

No.

FILED
JUN 9 19
MICHAEL RODAK, JR.

In the Supreme Court of the United States

OCTOBER TERM, 1979

SIDNEY A. DIAMOND, COMMISSIONER OF PATENTS AND TRADEMARKS, PETITIONER

v.

JOHN W. C. SHERWOOD

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF CUSTOMS AND PATENT APPEALS

WADE H. McCREE, JR.
Solicitor General
SANFORD M. LITVACK
Assistant Attorney General
ROBERT B. NICHOLSON
FREDERIC FREILICHER
Attorneys
Department of Justice
Washington, D.C. 20530

JOSEPH F. NAKAMURA
Solicitor
JERE W. SEARS
Deputy Solicitor
United States Patent and Trademark Office
Washington, D.C. 20231

In the Supreme Court of the United States

OCTOBER TERM, 1979

No.

SIDNEY A. DIAMOND, COMMISSIONER OF PATENTS AND TRADEMARKS, PETITIONER

v.

JOHN W. C. SHERWOOD

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF CUSTOMS AND PATENT APPEALS

The Solicitor General, on behalf of the Commissioner of Patents and Trademarks, petitions for a writ of certiorari to review the judgment of the United States Court of Customs and Patent Appeals in this case.

OPINIONS BELOW

The opinion of the Court of Customs and Patent Appeals (App. A, *infra*, *1a-21a*) is reported at 613 F.2d 809. The opinions of the Patent and Trademark Office Board of Appeals (App. C, *infra*, 23a-35a) and the opinion of the patent examiner (App. D, *infra*, *36a-40a*) are not reported.

JURISDICTION

The judgment of the Court of Customs and Patent Appeals was entered on January 10, 1980 (App. B, *infra*, 22a). On April 2, 1980, the Chief Justice extended the time to file a petition for a writ of certiorari to and including June 8, 1980. The jurisdiction of this Court is invoked under 28 U.S.C. 1256. *Gottschalk* v. *Benson*, 409 U.S. 63 (1972); *Dann* v. *Johnston*, 425 U.S. 219 (1976); *Parker* v. *Flook*, 437 U.S. 584 (1978).

QUESTION PRESENTED

Whether a computer program used in making a subsurface map useful in geophysical prospecting is patentable subject matter under 35 U.S.C. 101.

STATUTE INVOLVED

35 U.S.C. 101 provides:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

STATEMENT

On April 14, 1975, John W.C. Sherwood applied for a patent on a computer method for producing a subsurface map useful in geophysical prospecting (App. E, *infra*, 41a–63a).[1]

In geophysical prospecting for petroleum deposits it is common to use sonic (seismic) waves or signals to

---

[1]The invention is assigned to Chevron Research Company (C.C.P.A. Brief for Appellant at 1).

identify various subsurface geological formations (App. A, *infra*, 2a; App. E, *infra*, 42a). Sonic waves will be reflected upward by the formation and can be detected by geophones, mechanical devices that are positioned along the earth's surface (App. A, *infra*, 2a). The signals received by the geophones during a given period of time can be displayed on paper, with the geophone positions represented by a series of points extending horizontally, and the signals by wavy lines extending vertically from the geophone points (App. E, *infra*, 42a). These amplitude-time representations are called "seismic traces" (App. A, *infra*, 2a). An array of perhaps several hundred traces, representing signals received by many geophones, is called a "time section" (App. E, *infra*, 42a).

A seismologist using a time section can determine in a rough way the strata in the subsurface (App. E, *infra*, 42a–43a). But the time sections are not very accurate: for example, they do not reliably represent the depth of the formations, and do not show the abrupt ending of a stratum that has been cut off by a fault (*id.* at 43a–44a). To overcome these drawbacks, Sherwood devised a method for converting the time section data into data from which an accurate "depth section" could be made (*id.* at 42a, 46a–47a). He employed a sonogram, a well-known way of depicting seismic signals using traces (*id.* at 45a, 51a).[2] Sherwood's method involves sorting groups of seismic traces by the direction

---

[2] A sonogram is a set of traces representing discrete directions into the earth, in contrast to the seismic trace, which represents the signals from individual geophones or groups of geophones (App. E, *infra*, 44a).

of the origination of the signal. These trace groups, which may include traces received from widely-spaced locations, are summed to produce a set of sonogrammed traces. "Utilizing a seismic velocity function," derived from known mathematical equations (C.C.P.A. Brief for Appellant at 15 & n.17), segments of the sonogrammed traces are then correlated with the horizontal positions and depths of the subsurface formations that could have produced the signals. Finally, the traces are sonogrammed again (App. E., *infra*, 45a–51a). The result is a subsurface map that shows the subsurface formations as they are actually positioned (*ibid.*). What Sherwood calls the "migration process"—the process of relating the geophone signals recorded on the time section to their subsurface point of origination—may be carried out "on a large scale digital computer" (*id.* at 56a) and by using "presently available recording materials (either magnetic tapes or photographic films)" (*id.* at 47a).

The patent examiner rejected the invention as drawn to nonstatutory subject matter under 35 U.S.C. 101 (App, D, *infra*, 38a–40a).[3] He found that Sherwood's invention "comprises a program and algorithm utilized in conjunction with a digital computer" (*id.* at

---

[3] He also rejected the invention under 35 U.S.C. 112 because the best mode was not adequately disclosed (App. D, *infra*, 36a–38a). The Patent and Trademark Office Board of Appeals affirmed this ground of rejection (App. C, *infra*, 29a–32a), but the CCPA reversed, holding that the specification sufficiently described the best mode of carrying out the invention (App A, *infra*, 14a–16a). We do not ask this Court to review that conclusion. Accordingly, the only basis for rejecting the patent application remaining in the case is the Section 101 holding.

39a). He noted that "initiation and reception of seismic signals, computer operations on seismic signals and sonogramming for seismic records are old in the art" (*id.* at 38a).[4] The examiner concluded that, if allowed, the claims "would wholly preempt the mathematical process" and would "in practical effect be a patent on the mathematics, algorithm and program" (*id.* at 38a, 39a).

The Patent and Trademark Office Board of Appeals affirmed the rejection (App. C, *infra*, 24a-26a, 27a-29a). In its first decision, the Board observed that the claims, describing "the mathematical processing of data in accordance with equations given in [the] * * * specification," were directed to an algorithm as defined in *Gottschalk* v. *Benson*, 409 U.S. 63 (1972) (App. C, *infra*, 24a-25a). Although some of the claims contained post-solution activity—the actual plotting of the subsurface map—the Board found, on the authority of *Parker* v. *Flook*, 437 U.S. 584 (1978), that this could not "transform an unpatentable principle into a patentable process" (App. C, *infra*, 25a). On reconsideration, the Board stressed that the "only difference" between Sherwood's invention and a conventional time section "appears to lie in the calculations performed in connection with the * * * equations" in the specification (*id.* at 28a). Since, under *Flook*, these equations "may be considered to be part

---

[4] In his answer to Sherwood's brief on appeal to the Board, quoted by the court below, the examiner stressed that the novely to Sherwood's procedure "'is merely in sequencing of operations within a digital computer in response to external signals'" (App. A, *infra*, 6a-7a).

of the prior art," Sherwood had not claimed patentable subject matter (*id.* at 27a).

The Court of Customs and Patent Appeals (CCPA) reversed (App. A, *infra*, 21a). It did not overturn the Board's and examiner's finding that the only novel feature of the invention was the algorithm; instead, the court relied on its earlier opinion in *In re Diehr*, 602 F.2d 982, 988 (1979) for the conclusion that "[t]he novelty * * * of any element or even of all the elements or steps, or of the combination has no bearing on whether the process is encompassed by § 101." It thus rejected the Board's interpretation of *Flook* (App. A, *infra*, 18a–19a). The court reiterated its own test of patentability for claims involving mathematical algorithms (see, *e.g.*, *In re Freeman*, 573 F.2d 1237 (C.C.P.A. 1978)): "whether the claims taken in their entirety wholly preempt * * * [the] calculations, formulae or equations" in the claims (App. A, *infra*, 17a, 19a). Finding that the claims were not "mere methods (or means) for solving mathematical equations," but were for the conversion of "one physical thing [the electric signals from the geophones] into another physical thing [the sub-terranean map]" the court concluded that the claims recited patentable subject matter. (*id.* at 20a).

REASONS FOR GRANTING THE PETITION

The Court of Customs and Patent Appeals in the instant case again refused to apply the analysis of patent claims required under *Parker* v. *Flook*, 437 U.S. 584 (1978). The lower court instead chose to follow (App. A, *infra*, 17a–19a) the reasoning of its earlier cases,

including *In re Diehr*, 602 F.2d 982 (1979), cert. granted, No. 79–1112 (Mar. 17, 1980).

This case is not meaningfully distinguishable from *Diehr*. In each case the applicant's specification described a process using well-known machinery and steps, whose only novelty resided in a computer-implemented algorithm employing a known mathematical formula. In each case the Board properly applied the test laid down in *Parker* v. *Flook*: it set aside the computer-implemented algorithm, found everything else in the claims to be well-known, and concluded that the claims did not recite patentable subject matter. In neither case did the CCPA overrule the Board's analysis of the relation between the application and the prior art. Instead, in each case the lower court considered it dispositive that the claims "taken in their entirety" recited an improved process, and accordingly concluded that they recited patentable subject matter even though the applicant's only inventive contribution was a mathematical algorithm.

We have explained in our brief in *Diehr* why we contend that the Court of Customs and Patent Appeals' analysis flouts *Parker* v. *Flook*.[5] That court's refusal to accept governing precedent is repeated in this case.

---

[5] We are sending respondent copies of our briefs in *Diehr* and in *Diamond* v. *Bradley*, No. 79–855, which involves a closely related issue.

CONCLUSION

The petition should be held pending the Court's decision in *Diamond* v. *Diehr*, *supra*, and then disposed of as appropriate in light of that decision.

Respectfully submitted.

WADE H. MCCREE, JR.
Solicitor General

SANFORD M. LITVACK
Assistant Attorney General

ROBERT B. NICHOLSON
FREDERIC FREILICHER
Attorneys

JOSEPH F. NAKAMURA
Solicitor

JERE W. SEARS
Deputy Solicitor
United States Patent
and Trademark Office

JUNE 1980

APPENDIX A

United States Court of Customs and Patent Appeals

Appeal No. 79–579

Serial No. 567,458

IN THE MATTER OF THE APPLICATION OF
JOHN W. C. SHERWOOD

Decided: January 10, 1980

Before MARKEY, Chief Judge, RICH, BALDWIN and MILLER, Associate Judges, and NEWMAN, Judge.*

BALDWIN, Judge.

This is an appeal from the decision of the United States Patent and Trademark Office (PTO) Board of Appeals (board) affirming the rejections of all the claims as unpatentable under 35 USC 101 for being directed to nonstatutory subject matter and under 35 USC 112, paragraph one, for being based on a specification which fails to disclose the best mode. This application, serial No. 567,458,[1] was filed April 14, 1975,

---

*The Honorable Bernard Newman, United States Customs Court, sitting by designation.

[1]This case is a continuation of a series of applications; the earliest of which is serial No. 768,149, filed October 16, 1968.

and is entitled "Continuous Automatic Migration of Seismic Reflection Data with Waveform Preservation." We reverse.

THE INVENTION

A very common method of geophysical prospecting involves the production of a sonic (or seismic) wave in the earth. Certain subsurface geological formations, which may contain petroleum deposits, will reflect this induced seismic wave upward where it will be detected by variously spaced surface geophones. Each resulting geophone signal, as recorded, is merely an amplitude-time representation of that reflected sonic wave and is known as a "seismic trace." This invention involves apparatus (or "means for") and a method for producing a cross-sectional map (or "seismic depth section") depicting the position and shape of those subsurface formations.

Claim 15 is typical of the "means"-type claims which recite apparatus for plotting the desired map:

> 15. A system for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a seismic depth section consisting of a plurality of amplitude-versus-depth traces, so that events on the time section are migrated, both vertically and horizontally, into positions on said depth section corresponding to the actual spatial positions of the seismic reflectors in the subsurface, comprising:
>
> (a) automated data processing means for sonogramming said amplitude-versus-time traces, a group of traces at a time, to produce a plurality of sonograms each identified, indexed and stored with a respective horizontal pivot coordinate of a respective group of sonogrammed amplitude-

versus-time traces, and with a represented move-out,

(b) machine means for dividing each individual sonogram into a series of segments in accordance with a pre-selected seismic velocity function, and re-indexing and storing, also in accordance with said preselected velocity function, each of said series of segments into a particular storage zonelet representing a portion of said seismic depth section identified and indexed by a particular depth and horizontal coordinate, each of said series of divided and stored segments also being identified and indexed within a particular zonelet in accordance with a represented dip angle,

(c) machine means for automatically sonogramming said segments divided and stored within each of the zonelets to produce a final plurality of amplitude-versus-depth representations and

(d) machine means for directing and plotting the placement of said final representations on said seismic reflectors in said subsurface can be identified, in the vertical and horizontal location, by amplitude variations on said amplitude-versus-depth traces of said depth section.

Claim 21 is illustrative of the "means"-type claims which do not recite a final plotting "means."

21. An apparatus for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a plurality of machine generated, amplitude-versus-depth representations, so that events on the time section are migrated, both vertically and horizontally, according to the depth and horizontal coordinates of the seismic reflectors within a subsurface earth formation, [sic] they represent, comprising:

(a) automated data processing means for sonogramming said amplitude-versus-time traces,

a group of traces at a time, to produce a plurality of sonograms each identified by and indexed through a respective horizontal pivot coordinate and a represented moveout,

(b) automated means for machine dividing each of said individual sonograms into a series of segments in accordance with a seismic velocity function characteristic of the subsurface under study, and for each of a series of zonelets representing portions of said subsurface under study, said automated dividing means including separate means for placing, storing and indexing also in accordance with said seismic velocity function, said series of segments into said zonelets to provide said plurality of machine generated, amplitude-versus-depth representations.

The specification is largely directed to a discussion of analog computer apparatus suitable for producing the desired subsurface map by solving the disclosed equations. The specification also states:

> The final seismic depth section reproduced in FIGURE 8 was actually prepared by performing the method of the present invention on a large scale digital computer. It should be understood that the analog apparatus here shown as mechanical devices electrically interconnected are intended to assist in the understanding of the invention. The best mode contemplated by the inventor of carrying out the invention is to perform the processing steps of the invention on a large scale digital computer with the processed data imprinted into visible form on any of the presently available plotting devices.

THE REJECTION

The examiner stated in the Answer that the rejection was two-fold.

First, the examiner noted:

> Claims 15, 18–23, and 27 are rejected under 35 USC 112, paragraph one, as based upon an inadequate disclosure in that the best mode contemplated by the Applicant has not been described in sufficient detail to enable a person of ordinary skill in the art to make and use it. Applicant has failed to disclose *any computer hardware*, any *flow charts*, any *algorithms* or any *programs* with which his best mode would operate. [Emphasis in original.]
>
> * * * * *
>
> To achieve Applicant's invention a person skilled in the art would have to find digital hardware equipment able to carry out the invention, and devise flow charts and write programs which are not set out in the prior art.
>
> To achieve Applicant's objectives would thus require experimentation at length and an inordinate amount of speculation, industry and ingenuity, as the disclosure is merely an invitation to others to see if they can obtain Applicant's objectives which Applicant does not disclose how to obtain.

Secondly:

> Claims 15, 18–23, and 27 are rejected under 35 USC 100 and 101 as directed to a non-statutory class of invention. The present claims are directed to an automated digital processing system and method, and the *best mode disclosed is a programmed digital computer for carrying out the process*. Since initiation and reception of seismic signals, computer operations on seismic signals and sonogramming for a seismic records *are old in the art*, any patent that would issue on applicant's claims would wholly preempt the algorithm and program for carrying out the invention. This

would on practical effect be a patent on the algorithm and program themselves.

Applicant's assertion that the *Benson* decision [*Gottschalk* v. *Benson*, 409 U.S. 63, 175 USPQ 673 (1972)] upholds the patentability of the presently claimed invention fails to take into consideration the *entire* opinion as presented by Mr. Justice Douglas. Although the Court barred the conclusion that all software is unpatentable *per se*. 409 U.S. at 71, the Court did cite *the Report of the President's Commission, see supra,* and several law journal articles and concluded its opinion by admonishing the legislature that "considered action by the Congress is needed," 409 U.S. at 73. Thus, *Benson* has merely stated that some computer process may be patentable without stating any prerequisites for such patentability. The policy basis for the decision, however, precludes patentability where, as in the present application, the invention comprises a program and algorithm utilized in conjunction with a digital computer. *The method sought to be patented has as its best mode application by programmed digital computer.* This being the case, the instant claims if allowed would wholly preempt the mathematical process as described by applicant in the specification and would in practical effect be a patent on the mathematics, algorithm and program. [Emphasis in original.]

The examiner responded to applicant's brief in stating:

As regards to the rejection under 35 USC 100 and 35 USC 101 Appellant's distinguishing arguments are not without merit, but they fail to remove the instant invention from the scope of the decision in *Benson*. The novelty of the procedure herein claimed is merely in sequencing of operations within a digital computer in response to ex-

ternal signals, as to process seismic data in accordance with prior signals. The process is assertedly new merely in the nature of a program and algorithm.

* * * * *

Regarding appellant's arguments that the present invention can be carried out by an analog computer, it is noted that the claims read upon a general purpose digital computer implemented mode for carrying out the present invention. Furthermore, at page 24, lines 20–24 of the specification, applicant states that the best mode he contemplates for carrying out the invention is to perform the processing steps on a large scale digital computer. Concomitantly, the present claims, if allowed, would provide applicant with a patent monopoly on the digital processing mode, a mode unpatentable under 35 USC 100 and 35 USC 101.

Appellant's arguments as to the 35 USC 112, "best mode" rejection are directed to the proposition that "as long as there is a statement in the specification that the best mode is by way of a properly programmed digital computer there is no problem with this portion of Section of 112." (Brief at page 12). It is the examiner's contention however, that when an applicant states that a particular method of carrying out his invention is the best mode contemplated by him as of the time he executes the application, he must disclose such an invention so as to enable one of ordinary skill in the art to make and use it. Only with such a requirement would inventors be restrained from applying for patents while at the same time concealing from the public how to make and use such preferred embodiments. Appellant's enabling disclosure of the non-preferred embodiment, i.e. the analog does not suffice to replace the requisite disclosure of the preferred embodiment.

It is seemingly clear that a reasonable level of ordinary skill in programming should be the capability of proceeding from adequately detailed algorithms and flow charts to an operative program. The detailing thereof should be at least to the level where all mathematical formulae, as well as all logic for the transformation or manipulation of data have been specified in terms commensurate with the usual subroutines available in the computer languages. *The specification fails to provide any such requisite detailing.* [Emphasis in original.]

THE BOARD

The board, in a first opinion, considered only the §101 rejection and stated:

For the purposes of discussion, we address the details of claim 15 although our remarks are germane to the remainder of the claims also. Features (a)–(d), although characterized in "means" plus function language, describe the mathematical processing of data in accordance with equations given in appellant's specification * * * for the purposes of reaching a solution to a seismic problem, namely, the generation of a seismic depth section indication. These features of claim 15 and the comparable subject matter of the remainder of the claims are directed to an algorithm within the definition provided in *Gotschalk v. Benson* * * *

* * * * *

We think the decision in *Parker v. Flook*, 437 US. . . ., 198 USPQ 193 (1978), is supportive of the position taken by the examiner. As the Court makes clear, appellant's algorithm can be assumed to be within the prior art. Moreover, the use of the calculation in a post solution activity cannot transform an unpatentable principle into a patentable process.

We recognize the instant claims are within the technological arts, and have an end use, however, the Court in Flook, footnote 18, makes the following statement:

> "Very simply, our holding today is that a claim for an improved method of calculation, even when tied to a specific end use, is unpatentable subject matter under §101."

We consider that the Court's observation is applicable to the facts of the instant case.

We affirm the rejection.

In a second opinion, initiated by a request for reconsideration, the board discussed the §101 rejection. In this initial portion of the opinion (all members joining this section), the board responded to a number of appellant's arguments concerning that rejection:

> Beginning with the second paragraph of page 2 of the most recent paper, appellant urges that he produced a final *new* depth display previously unachieved. Appellant * * * admits that producing seismic time sections such as shown in Figure 1 is old in the art. Appellant's claimed subject matter appears directed to the data processing incident to the use of appellant's equations set forth on pages 18, 20 and 22, as we indicated in our original decision.
>
> We reiterate that, notwithstanding the purported novelty urged, the subject matter of the equations as claimed must be considered to be algorithmic and that, as the Court indicated in *Flook*, may be considered to be part of the prior art for the purposes of considering the compliance of appellant's claimed subject matter with regard to the statute.
>
> In the same paragraph, appellant contrasts the magnitude of the data processing incident to the practice of his invention with that which appeared

to be required in the *Flook* [*Parker* v. *Flook*, 437 U.S. 584, 198 USPQ 193 (1978)] case. Appellant has not adverted to any language in that decision however which sets out the magnitude of data processing as a criterion for determining whether claimed subject matter falls within 35 USC 100 and 101 and we know of none.

On page 3 of the request, appellant maintains:

> "It should be brought to the Board's attention that the end-product of *Flook* was a number, and the Supreme Court indicated that the *only* difference between the claimed method and those available in the art was in the formula there presented."

Further, at the bottom of page 3, employing claim 15 as an example, appellant contrasts the detail set out in his claimed subject matter with the nature of the disclosure in the *Flook* patent application as commented upon by the Court in that case. Appellant urges that he produced not an improved method of calculation, but a new depth section represented by a series of novel steps. [Emphasis in original.]

To these matters we say that in appellant's application, the end product, as disclosed in Figure 2, is a seismic trace "produced by the method of the present invention from the data represented in Figure 1." (Specification, page 5, lines 20–22). We repeat, the only difference between the claimed subject matter which produces an output such as Figure 2 and a conventional seismic time section as shown in Figure 1 appears to lie in the calculations performed in connection with the aforementioned equations.

In response to appellant's contentions that the best mode was adequately disclosed, a majority (two out of three members) noted in the final part of the opinion:

> Appellant in his specification thus indicates (a) that "in most cases" the invention will be performed by a large storage capacity high speed digital computer, and (b) that Fig. 8 was obtained in such a fashion.
>
> * * * * *
>
> We think (a) coupled with (b) constitute an indication that the best mode of appellant's invention is a digital one which mode has been concealed, the concealment being of the nature described in *In re* Gay, 50 CCPA 725, 309 F.2d 769, 135 USPQ 311 (1962), cited by appellant. See also *In re* Hay, 534 F.2d 917, 189 USPQ 790 (CCPA, 1976).

Additionally, the majority discussed two affidavits submitted by appellant in support of the argument that the best mode was adequately disclosed.

With regard to the Miller affidavit, [2] it is not

---

[2]The Miller affidavit essentially stated that, on the basis of a presentation given by appellant in 1967, a program for a digital computer using a Fourier transform method was written by affiant and three co-workers and successful computer runs made with the program. Subsequently, affiant alone wrote another program using the disclosed "sonogram" method. It was the opinion of the affiant that persons having education and work experience similar to his own (B.S. & M.S. in electrical engineering, 5 years in the "design and development of geophysical recording instrumentation and geophysical recording instrumentation" and 4 years of FORTRAN IV programming) would be able to easily write a successful computer program to carry out the method of the disclosure. Further, it was opined:

> [B]ased on his personal experience and observations, the English and mathematical statements, standing alone in said specification. and even without the physical analog embodiment, describe in such full, clear, concise and exact terms that a person of electrical engineering background with some experience in programming (a common background for workers in geophysical instrumentation and data processing) would be able to make and use a computer program for carrying out the method of the described invention.

clear whether the work performed as described in paragraph 8 thereof was done solely as a result of the explanation provided by Dr. Sherwood as described in paragraphs 4–7 or whether subsequent interaction by the affiant with Dr. Sherwin was required in order to complete the project.

It appears that affiant, together with coworkers participated in preparing a Fourier transform program, following which affiant prepared a sonogram program. The time employed in these endeavors is not set forth. Further, no facts or evidence are adduced from which a determination can be made that the latter program was successful as averred and that it corresponded satisfactorily to the claimed subject matter. It thus cannot be determined whether or not undue experimentation was required in the effort described in paragraph 8 and accordingly, affiant's averment must be considered to be conclusory in character.

Averments 9–11 are not supported by facts or evidence of record and thus must also be considered as conclusory.

As for the Cardwell affidavit, [3] no data or evidence is adduced to substantiate the averments

---

[3]The Cardwell affidavit (after establishing the not insubstantial credentials of the affiant) discusses the kind and quality of information that, in the affiant's opinion, is desirable in communicating the manner of solving a problem using a computer program. The essence of the affidavit noted:

> 9. That the desirable elements of human-to-human communication in formulating, programming, and using computer programs are:
>
> (1) an over-all statement (in English and mathematics) of the problem to be solved,
>
> (2) the specification of the expected input, and desired output, quantities,
>
> (3) the specification of the forms of input and output,
>
> (4) the specification of the significant internal parameters of the process,

made in paragraphs 10 and 11 and these must for this reason be considered conclusory.

One member of the board concurred in the result reached by the majority in the best mode issue, but advanced other reasoning in affirming the rejection. He considered the fact that appellant produced the seismic depth section found in Figure 8 of the specification via a digital computer to be evidence of concealment. Specifically, he stated:

> [T]he appellant tells us that the "best mode" contemplated by him of carrying out the invention involves the use of a digital computer and has presented the results in Figure 8 of the drawings. Hence, the appellant must have known more about this embodiment than he disclosed. This

---

(5) a set of statements of the mathematical and physical assumptions underlying the sought solution of the stated problem,

(6) the writing of the relevant mathematical solution equations,

(7) the specification of the conditional logic (according to which control is to be transferred between program statements depending on computed results). (Elements (5), (6) and (7) constitute the "algorithm" or the "trick" by which the problem, which may never have been solved at all before, may now be solved.)

10. That it is his opinion, based on his personal experiences and observations, that in the specification of the patent application, Serial No. 768,149, filed October 16, 1968, the English statements, the figures showing forms of input and output, and the mathematical statements, of the specification of the patent application, Serial No. 768,149, filed October 16, 1968, comprehend all the elements (1) to (7) mentioned above with a completeness that is unusual, and beyond what is necessary, for the human-to-human communication that precedes the writing of computer programs to solve problems such as that treated in the subject specification.

failure to disclose what was known about the preferred embodiment of the invention at the time the present application was filed constitutes concealment prohibited by the best mode clause of the first paragraph of 35 USC 112.

OPINION

§ *112—Best Mode*

As was noted in *Weil* v. *Fritz*, 601 F.2d 551, 555, 202 USPQ 447, 450 (CCPA 1979 "[i]t is not up to this court to state *how* the applicant displays his information [disclosing best mode], but only, under proper circumstances, to review *whether* he has done so adequately under the statute." [Emphasis in original.]

This case presents the question of whether appellant has "adequately" disclosed the contemplated best mode.

The board correctly recognized that there is no objective standard by which to judge the adequacy of a best mode disclosure.[4] Instead, only evidence of concealment (accidental or intentional) is to be considered. That evidence, in order to result in affirmance of a best mode rejection, must tend to show that the *quality* of an applicant's best mode disclosure is so poor as to effectively result in concealment.[5]

---

[4] The question of a specification's adequacy in this context is in no way related to the question of the specification's sufficiency in complying with the enablment requirement. *In re Gay*, supra at 731, 309 F.2d at 772, 135 USPQ at 315. Occasionally, the analysis of the technical information may be similar.

[5] A similar standard has been applied by other courts. For instance, in *Union Carbide* v. *Borg-Warner*, 550 F.2d 355, 193 USPQ 1 (6th Cir. 1977), the generic disclosure of an "extruder"

The evidence in this case, which is said to be probative of concealment, consists of the inventor's notation in the specification that the use of a digital computer was the best mode, the specification's Fig. 8 (a subterranean map produced by a digital computer) and the Miller affidavit which indicated the existence of useable computer programs.

Certainly the evidence unequivocably shows the existence of a working computer program as of the filing date. The board accurately notes that the inventor had more information in his possession concerning his contemplated best mode than he disclosed in the specification. Whether failure to disclose a listing of that known computer program is fatal is the question.

In general, writing a computer program may be a task requiring the most sublime of the inventive faculty or it may require only the droning use of a clerical skill. The difference between the two extremes lies in the creation of mathematical methodology to bridge the gap between the information one starts with (the "input") and the information that is desired (the "output"). If these bridge-gapping tools are disclosed, there would seem to be no cogent reason to require

---

apparatus as the best mode was insufficient in view of evidence that the inventor considered a special type of extruder to be necessary and desirable for practice of the invention. Similarly, in *Dale Electronics* v. *R.C.L. Electronics*, 488 F.2d 382, 180 USPQ 225 (1st Cir. 1973), the disclosure of the class "epoxys, phenolics or silicones" as a "recommended hardenable insulative material" was found to be an inadequate disclosure of the best mode in that the inventor testified that a number of materials within that class did not work and additionally he knew of a specific undisclosed material, Rogers RX600, that worked very well.

disclosure of the menial tools known to all who practice this art.[6]

The Cardwell affidavit outlines in a very reasonable manner the human-to-human elements necessary in communicating the concepts of a particular computer program to one having ordinary (or, indeed, less than ordinary) skill in this art. The specification provides the general mathematical equations used and teaches the further "trick" of chopping the physical input seismic traces into segments via a mathematical manipulation.[7] For this reason, the specification in our view delineates the best mode in a manner sufficient to require only the application of routine skill to produce a workable digital computer program.[8] Therefore, the quality of appellant's disclosure is not so poor as to result in the concealment of the best mode.

---

[6] In assessing any computer-related invention, it must be remembered that the programming is done in a computer language. The computer language is not a conjuration of some black art, it is simply a highly structured language. Analogously, if a person were to express a complete thought in German, it would be no trick for a translator to convert that thought into a palpable English form. The thought, thus expressed, might not be worthy of Shakespeare, but it would be understandable to one who uses the English language. Similarly, the conversion of a complete thought (as expressed in English and mathematics, i.e., the known input, the desired output, the mathematical expressions needed and the methods of using those expressions) into the language a machine understands is necessarily a mere clerical function to a skilled programmer.

[7] The step of dividing the traces into small segments is disclosed to provide the advantageous result of allowing the detection of small geologic subsurface irregularities otherwise undetectable.

[8] Taking into account the expert opinions found in the two affidavits, it would appear that the detailed disclosure of the analog method in combination with the suggestion that a digital method should be used might be more enlightening to one hav-

§ *101*

The technical subject matter and statutory rejection in this case are quite closely related to those considered in *In re Johnson*, 589 F.2d 1070, 200 USPQ 199 (CCPA 1978). The legal analysis here is, for that reason, quite similar in effect and method to that in *Johnson*.

In any event, as was done in *Johnson*, the analysis of the claims should start with the two-pronged test accepted by the full court in *In re Freeman*, 573 F.2d 1237, 197 USPQ 464 (CCPA 1978), i.e., first, determine whether the claims directly or indirectly recite process steps[9] which are themselves calculations, formulae or equations, and; secondly, determine whether the claims taken in their entirety wholly preempt these calculations, formulae or equations. *In re Maucorps*, supra; *In re Diehr*, 602 F.2d 982, 203 USPQ 44 (CCPA 1979).

The solicitor, however, urges that *Parker* v. *Flook*, supra, modified, to the point of extinction, the second step of the Freeman "nutshell" analysis.[10] The solicitor apparently would substitute, as a second stage of analysis, a consideration of each of the steps in a process in isolation and determine whether each is "old or con-

---

ing ordinary skill in the art than the computer listing or flow chart required by the PTO. We view the PTO's requirement as quite formalistic in view of the verbal flow chart provided by appellant in the specification. In any event, the touchstone is the content, not its form.

[9] In *Freeman*, for the purpose of testing compliance with §101, process and "means for" claims were treated in the same manner. W do the same here. *In re Maucorps*, ___ F.2d ___ 203 USPQ 812 (CCPA 1979).

[10] This "nutshell" analysis follows that found in *Gottschalk* v. *Benson*, 409 U.S. 63, 175 USPQ 673 (1973).

ventional."[11] Indeed, the PTO brief is little more than a catalog of steps considered to be old and steps considered to be mathematical in nature. This manner of viewing only portions of claims certainly is not countenanced in a fair reading of *Parker* v. *Flook*. The Court specifically noted therein "[o]ur approach to respondent's application is, however, not at all inconsistent with the view that a patent claim must be considered as a whole." *Id.* at 594, 198 USPQ at 199. As was

---

[11] The Supreme Court in *Parker* v. *Flook* discussed *Mackay Radio and Telegraph* v. *Radio Corporation of America*, 306 U.S. 86, 40 USPQ 199 (1939) and pointed to the analysis therin as proper in cases involving this issue. We would observe that use of the solicitor's analysis on the claims in *Mackay:*

> [4] "15. An antenna comprising a pair of relatively long conductors disposed with respect to each other at an angle substantially equal to twice
>
> $$50.9\left(\frac{\int}{\lambda}\right)^{-0.513}$$
>
> degrees, $\int$ being the length of the wire and λ the operating wave length in like units, and means in circuit with said antenna for exciting the conductors in phase opposition whereby standing waves of opposit instantaneous polarity are formed on the conductors throughout their length."
>
> Claim 16 claims an antenna arranged in conformity to the empirical formula, as in Claim 15, with "a similar parallel pair of conductors spaced an odd number of quarter wave lengths away from said first mentioned pair * * *" These parallel wires constitute the "reflector," which, as already noted, was old in the art.
>
> [*Id.* at 96 n.4, 40 USPQ at 203 n.4.]

would result in a finding that those claims were unpatentable since the "conductors" were old and the equation is to be ignored. The Supreme Court has told us by its decision in *Mackay Radio* that the *interrelationship* of equations and other claim portions is of paramount importance. *Parker* v. *Flook* has no such interrelationship in that the steps of the claims only produced a number.

noted in *In re Diehr*, supra at 988, 203 USPQ at 51, "[t]he novelty * * * of any element or even of all the elements or steps or of the combinaton has no bearing on whether the process is encompassed by §101."[12]

In any event, appellant concedes that the first step of the *Freeman* test is met. Each of the claims recites "re-indexing and storing" in accordance with the "seismic velocity function." An examination of the specification does indicate that certain mathematical equations are used in conjunction with such steps. The claims must be said to include the indirect recitation of a mathematical equation.

The second *Freeman* step requires analysis of a claim, as a whole, "to determine whether or not it merely defines a method of solving a mathematical problem. If it does not, then it defines statutory subject matter." *In re Johnson*, supra at 1079, 200 USPQ at 208-208.

The solicitor makes the argument that a number of the claims[13] are *only* mathematical in nature. It is said

---

[12]The PTO contends that this statement in *Diehr* conflicts with *Parker* v. *Flook*. We disagree. We believe the Court adequately treated such dichotomy in noting:

> This case turns entirely on the proper construction of § 101 of the Patent Code, which describes the subject matter that is eligible for patent protection. *It does not involve the familiar issues of novelty and obviousness* that routinely arise under §§ 102 and 103 when the validity of a patent is challenged. [Emphasis added. *Id.* at 588, 198 USPQ at 196.]

[13]The remainder of the claims, 15 and 18-20, provide for plotting the "refined signals" and are apparently conceded to be more than merely mathematical in nature. Nevertheless, the plotting step is said to be only a "post-solution activity" and, in the solicitor's view of *Parker* v. *Flook*, additional evidence that these claims recite non-statutory subject matter.

that as the appellant's "claim preambles indicate, appellant is really mathematically converting one set of numbers into a new set of numbers."[14] We do not agree with such a characterization. Each of the claim preambles recites a system for converting a "seismic time section consisting of * * * amplitude-versus-time seismic traces" (these seismic traces are electrical signals from geophones, i.e., *physical* apparitions, or particular patterns of magnetization on magnetic tape, i.e., the pattern of the magnetization being a *physical* manifestation, or a *physical* line on paper chart) into a "seismic depth section consisting of * * * amplitude-versus-depth traces" (a subterranean cross-sectional map). The claimed invention, contrary to the solicitor's arguments, converts one physical thing into another physical thing just as any other electrical circuitry would do.

Accordingly, we see no basis for adjudging any of the claims to be mere methods (or means) for solving mathematical equations and find the claims to be within the bounds of § 101.

---

[14]The board relied on a somewhat similar analysis when it noted that the "only difference between the claimed subject matter which produces an output such as Figure 2 and a conventional seismic time section as shown in Figure 1 appears to lie in the calculations performed in connection with the aforementioned equations." Even if this is an attempt to follow *Parker* v. *Flook*, it is an overbroad recital of the Court's analysis.

The error of this broadbrush analysis is amply exemplified by its simple application to the claims found patentable by the Supreme Court in *Mackay Radio*, supra at footnote 11. In that case, the only difference between the claimed antenna and prior art antennas lay in the calculation used to describe the physical relationship between the elements. Under the board's analysis, such a claim would be nonstatutory.

CONCLUSION

We *reverse* the decision of the board with regard to each issue.

REVERSED

APPENDIX B

United States Court of Customs and Patent Appeals

Mandate

No. 79-579

IN THE MATTER OF THE APPLICATION OF
JOHN W. C. SHERWOOD

Serial No. 567,458

ON APPEAL from the Board of Appeals
This CAUSE having been heard and considered, it is ORDERED and ADJUDGED: Reversed

DATED January 10, 1980

A TRUE COPY GEORGE E. HUTCHINSON,

TEST:
CLERK, UNITED STATES COURT OF CUSTOMS
AND PATENT APPEALS
CERTIFIED THIS 1ST DAY OF FEBRUARY 1980

BY _____
/S/ GEORGE E. HUTCHINSON

APPENDIX C

OPINION AND DECISION OF BOARD OF APPEALS, SEPTEMBER 27, 1980

Before Burns and Spencer, Examiners-in-Chief, and Lindquist, Acting Examiner-in-Chief.

Burns, Examiner-in-Chief.

This is an appeal from the final rejection of claims 15, 18-23 and 27, constituting all of the claims presently in this case.

The disclosure is directed to method and apparatus for processing seismic signals best understood from a consideration of claim 15:

> 15. A system for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a seismic depth section consisting of a plurality of amplitude-versus-depth traces, so that events on the time section are migrated, both vertically and horizontally, into positions on said depth section corresponding to the actual spatial positions of the seismic reflectors in the subsurface, comprising:
>
> (a) automated data processing means for sonogramming said amplitude-versus-time traces, a group of traces at a time, to produce a plurality of sonograms each identified, indexed and stored with a respective horizontal pivot coordinate of a respective group of sonogrammed amplitude-versus-time traces, and with a represented move-out,
>
> (b) machine means for dividing each individual sonogram into a series of segments in accordance with a preselected seismic velocity function, and re-indexing and storing, also in accordance with said preselected velocity function, each of said

series of segments into a particular storage zonelet representing a portion of said seismic depth section identified and indexed by a particular depth and horizontal coordinate, each of said series of divided and stored segments also being identified and indexed within a particular zonelet in accordance with a represented dip angle,

(c) machine means for automatically sonogramming said segments divided and stored within each of the zonelets to produce a final plurality of amplitude-versus-depth representations and

(d) machine means for directing and plotting the placement of said final representations on said seismic depth section, so that said seismic reflectors in said subsurface can be identified, in the vertical and horizontal location, by amplitude variations on said amplitude-versus-depth traces of said depth section.

REJECTION UNDER 35 USC 100 AND 101

The examiner has rejected all of the claims as being nonstatutory under the above sections of the statute as directed to an automated digital processing system and method because the best mode disclosed is a programmed digital computer for carrying out the process.

We have reviewed all of the authorities adduced by appellant in his brief and reply brief. For the purposes of discussion, we address the details of claim 15 although our remarks are germane to the remainder of the claims also. Features (a)–(d), although characterized in "means" plus function language, describe the mathematical processing of data in accordance with equations given in appellant's specification, pages 18, 20 and 22, for the purposes of reaching a solution to a seismic problem, namely, the generation of a seismic

depth section indication. These features of claim 15 and the comparable subject matter of the remainder of the claims are directed to an algorithm within the definition provided in *Gottschalk v. Benson*, 409 US 63, 175 USPQ 673 (CCPA, 1972). That the subject matter of the claims is characterized in "means" plus function form is of no moment for the Court *In re* Freeman, 197 USPQ 464, (CCPA, 1978) did not perceive this to be a satisfactory distinction:

> "Though a claim expressed in 'means for' (functional) terms is said to be an apparatus claim, the subject matter as a whole of that claim may be indistinguishable from that of method claim drawn to the steps performed by the 'means.' . . .
>
> "We agree with the solicitor's contention that if allowance of a method claim is proscribed by Benson, it would be anomalous to grant a claim to apparatus encompassing any and every 'means for' practicing that very method."

We think the decision in *Parker v. Flook*, 437 U.S. . . . ., 198 USPQ 193 (1978), is supportive of the position taken by the examiner. As the Court makes clear, appellant's algorithm can be assumed to be within the prior art. Moreover, the use of the calculation in a post solution activity cannot transform an unpatentable principle into a patentable process.

We recognize the instant claims are within the technological arts, and have an end use, however, the Court in *Flook*, footnote 18, makes the following statement:

> "Very simply, our holding today is that a claim for an improved method of calculation, even when tied to a specific end use, is unpatentable subject matter under § 101."

We consider that the Court's observation is applicable to the facts of the instant case.

We affirm the rejection.

REJECTION UNDER 35 USC 112

The examiner has also rejected the claims under this section of the statute. We find it unnecessary to address this issue at this time in view of our holding above.

SUMMARY

We have sustained rejection of all claims under 35 USC 100 and 101 and accordingly, have found it unnecessary to make a holding with regard to the rejection based upon 35 USC 112.

The decision of the examiner is affirmed.

AFFIRMED

WALTER W. BURNS
Examiner-in-Chief
RICHARD A. SPENCER
Examiner-in-Chief
WILLIAM F. LINDQUIST
Examiner-in-Chief
(Acting)

} BOARD OF APPEALS

OPINION AND DECISION OF BOARD OF APPEALS, JANUARY 15, 1979

Before Burns and Spencer, Examiners-in-Chief, and Lindquist, Acting Examiner-in-Chief.

Burns, Examiner-in-Chief.

UPON REQUEST FOR RECONSIDERATION

35 USC 101

In a paper filed October 16, 1978, appellant requests that we reconsider our decision dated September 27, 1978, wherein we affirmed the final rejection of claims 15, 18–23 and 27 under 35 USC 100 and 101 based upon the position taken by the Court in *Gottschalk v. Benson*, 409 US 63, 175 USPQ 673 (1972) and *Parker v. Flook*, 437 US . . . ., 198 USPQ 193 (1978).

Beginning with the second paragraph of page 2 of the most recent paper, appellant urges that he produced a final *new* depth display previously unachieved. Appellant, specification page 1 beginning with paragraph 2, admits that producing seismic time sections such as shown in Figure 1 is old in the art. Appellant's claimed subject matter appears directed to the data processing incident to the use of appellant's equations set forth on pages 18, 20 and 22, as we indicated in our original decision.

We reiterate that, notwithstanding the purported novelty urged, the subject matter of the equations as claimed must be considered to be algorithmic and that, as the Court indicated in *Flook*, may be considered to be part of the prior art for the purposes of considering the compliance of appellant's claimed subject matter with regard to the statute.

In the same paragraph, appellant contrasts the magnitude of the data processing incident to the practice of his invention with that which appeared to be required in the *Flook* case. Appellant has not adverted to any language in that decision however which sets out the magnitude of data processing as a criterion for determining whether claimed subject matter falls within 35 USC 100 and 101 and we know of none.

On page 3 of the request, appellant maintains:

> "It should be brought to the Board's attention that the end-product of *Flook* was a number, and the Supreme Court indicated that the *only* difference between the claimed method and those available in the art was in the formula there presented."

Further, at the bottom of page 3, employing claim 15 as an example, appellant contrasts the detail set out in his claimed subject matter with the nature of the disclosure in the *Flook* patent application as commented upon by the Court in that case. Appellant urges that he produced not an improved method of calculation, but a new depth section represented by a series of novel steps.

To these matters we say that in appellant's application, the end product, as disclosed in Figure 2, is a seismic trace "produced by the method of the present invention from the data represented in Figure 1." (Specification, page 5, lines 20–22). We repeat, the only difference between the claimed subject matter which produces an output such as Figure 2 and a conventional seismic time section as shown in Figure 1 appears to lie in the calculations performed in connection with the aforementioned equations.

While we have addressed specific features of appellant's claims for discussion, we recognize that, in de-

termining compliance with the statute, each claim must be considered as a whole. Our treatment of appellant's claims we do not believe to be inconsistent with this principle, cf. *In re* Christensen, 478 F.2d 1392, 178 USPQ 35 (CCPA, 1973) and Flook, supra.

Appellant's request for reconsideration in connection with the rejection under 35 USC 100 and 101 is granted to the extent that we have in fact reviewed our original decision in the light of the remarks made in his most recent paper but is denied as to making any change therein.

35 USC 112

In the final paragraph of his most recent paper, appellant requests that we render a decision upon the rejection under 35 USC 112, which in the interest of expedition we omitted. His request as to this matter is granted.

In the final rejection and also in the answer, page 2, the examiner states the rejection as follows:

> ". . . as based upon an inadequate disclosure in that the best mode contemplated by the Applicant has not been described in sufficient detail to enable a person of ordinary skill in the art to make and use it. Applicant has failed to disclose *any computer hardware*, any *flow charts*, any *algorithms* or any *programs* with which his best mode would operate."

We note that appellant on specification page 12, beginning at line 23, makes the following statement:

> ". . . The analog form has here been shown because it is more readily comprehendable in terms of its ability to perform the steps of the method of this invention. However, it will become evident that the method can also be, and in most cases will be,

performed employing a large storage capacity, high speed computer between the field tapes and the final seismic section."

Further, at page 23, line 27:

". . . Indeed, after the method has been described, it is within the present skill of the art to carry out the entire method on a large scale digital computer such as the IBM 360/50."

On page 24, at line 14:

"The final seismic depth section reproduced in FIGURE 8 was actually prepared by performing the method of the present invention on a large scale digital computer."

Appellant in his specification thus indicates (a) that "in most cases" the invention will be performed by a large storage capacity high speed digital computer, and (b) that Fig. 8 was obtained in such a fashion.

Appellant has not designated any portion of the specification which recites that he conceives the best mode of his invention to be practiced upon the Figs. 5 and 6 analog embodiment, a fact not surprising considering the possible engineering requirements implicit in the presentation of magnetic pick-up heads such as 15a-c and 35 a-c proximate to the drums 10 and 20 with sufficient precision to obtain satisfactorily precise recording and reading, at the same time allowing for the movement of the "a" and "c" heads across the cylindrical surface of the drums as imparted by their rotation about axes 17 and 37.

We think (a) coupled with (b) constitute an indication that the best mode of appellant's invention is a digital one which mode has been concealed, the concealment being of the nature described in *In re* Gay, 50 CCPA 725, 309 F.2d 769, 135 USPQ 311 (1962),

cited by appellant. See also *In re* Hay, 534 F.2d 917, 189 USPQ 790 (CCPA, 1976).

Of those cases which appellant his cited in support of his position, *In re* Prater et al., 56 CCPA 1381, 415 F.2d 1393, 162 USPQ 541 (1969), is given by appellant as an example of a case wherein an analog system was effectively used to demonstrate the principles of the invention. In that case, it does not appear that a "best mode" rejection was made under 35 USC 112. The rejection under that section of the statue was based upon paragraph 2 rather than paragraph 1 as here. The case is accordingly not considered apposite. While *In re* Bernhart et al., 57 CPPA 737, 417 F.2d 1395, 163 USPQ 611 (1969) and *In re* Noll, 545 F.2d 141, 191 USPQ 721 (1976), involved a first paragraph rejection under 35 USC 112, again it does not appear that the "best mode" language of the statute was invoked. No rejection under 35 USC 112 appears to have been under consideration in *In re* Chatfield, 545 F.2d 152, 191 USPQ 730 (1976).

With regard to the Miller affidavit, it is not clear whether the work performed as described in paragraph 8 thereof was done solely as a result of the explanation provided by Dr. Sherwood as described in paragraphs 4-7 or whether subsequent interaction by the affiant with Dr. Sherwin was required in order to complete the project.

It appears that affiant, together with co-workers participated in preparing a Fourier transform program, following which affiant prepared a sonogram program. The time employed in these endeavors is not set forth. Further, no facts or evidence are adduced from which a determination can be made that the lat-

ter program was successful as averred and that it corresponded satisfactorily to the claimed subject matter. It thus cannot be determined whether or not undue experimentation was required in the effort described in paragraph 8 and accordingly, affiant's averment must be considered to be conclusory in character.

Averments 9–11 are not supported by facts or evidence of record and thus must also be considered as conclusory.

As for the Cardwell affidavit, no data or evidence is adduced to substantiate the averments made in paragraphs 10 and 11 and these must for this reason be considered conclusory.

In regard to the affidavits, we have reviewed the matters treated in the amendment after final rejection filed January 10, 1977, paper no. 11, in particular beginning with page 7 thereof, which we have considered as part of appellant's argument. Arguments cannot, of course, take the place of evidence, *In re* Schulze, 52 CCPA 1422, 346 F.2d 600, 145 USPQ 716 (1965).

In view of the foregoing, we sustain the rejection under 35 USC 112, paragraph 1, for the reason that the disclosure fails to set forth adequately the best mode contemplated by appellant.

Appellant's request for modification of our original decision as to the rejection under 35 USC 112 is granted to the extent that we modify our decision by affirming the examiner's rejection.

DECISION MODIFIED, AFFIRMED

WALTER W. BURNS
Examiner-in-Chief
RICHARD A. SPENCER
Examiner-in-Chief

BOARD OF APPEALS

Lindquist, Acting Examiner-in-Chief, concurring.

I agree with the conclusion of the majority that the disclosure of the present application fails to comply with the best mode requirement of the first paragraph of 35 USC 112 but cannot fully subscribe to their reasons for reaching this conclusion.

The position of the examiner, as I understand it, is that the disclosure does not comply with the best mode clause because the disclosure is not enabling when the invention is practiced by the use of a digital computer. It is my opinion that the examiner is confusing the best mode requirement with the enablement requirement of the first paragraph of 35 USC 112. Clearly, the two requirements are separate and distinct. *In re* Gay, 50 CCPA 725, 309 F.2d 769, 135 USPQ 311 (hereinafter *Gay*).

The Court of Customs and Patent Appeals went on to say in *Gay* that:

> "Manifestly, the sole purpose of this latter [best mode] requirement is to restrain inventors from applying for patents while at the same time concealing from the public preferred embodiments of their inventions which they have in fact conceived."

Hence, the only inquiry to be made with respect to the best mode requirement revolves around a determination of whether there is evidence to indicate that an inventor has concealed preferred embodiments of his invention. Thus, an inventor, at the time the application was filed, may have envisioned other, perhaps better or preferred, embodiments for practicing the invention but had not attempted to practice the invention by means of these other embodiments. In that situation, the mention of these other embodiments

satisfies the best mode requirement. That is to say, the inventor in that situation concealed nothing; he disclosed all he knew. Whether this disclosure of other possible embodiments for practicing the invention satisfies the enablement requirement is of no moment, so long as there is a disclosed embodiment which does comply with the enablement requirement.

Turning now to the case at hand, the majority referred to three portions of the specification on page 4 of this response to the appellant's request for reconsideration. The quotations from pages 12 and 23 of the specification alone do not constitute evidence of concealment. The last quotation was taken from the first full paragraph on page 24 of the specification which reads as follows:

> "The final seismic depth section reproduced in FIGURE 8 was actually prepared by performing the method of the present invention on a large scale digital computer. It should be understood that the analog apparatus here shown as mechancial devices electrically interconnected are intended to assist in the understanding of the invention, The best mode contemplated by the inventor of carrying out the invention is to perform the processing steps of the invention on a large scale digital computer with the processed data printed into visible form on any of the presently available plotting devices."

In my opinion, this disclosure constitutes evidence of concealment. That is to say, the appellant tells us that the "best mode" comtemplated by him of carrying out the invention involves the use of a digital computer and has presented the results in Figure 8 of the drawings. Hence, the appellant must have known more about this embodiment than he disclosed. This failure

to disclose what was known about the perferred embodiment of the invention at the time the present application was filed constitutes concealment prohibited by the best mode clause of the first paragraph of 35 USC 112.

WILLIAM F. LINDQUIST
Examiner-in-Chief
(Acting)

BOARD OF APPEALS

APPENDIX D

LETTER OF EXAMINER, SEPTEMBER 9, 1976

* * * * *

1) Claims 15, 18–23, 25 and 27 are rejected under 35 USC 112, paragraph one, as based upon an inadequate disclosure in that the best mode contemplated by the applicant has not been described in sufficient detail to enable a person of ordinary skill in the art to make and use it. Applicant has failed to disclose any computer hardware, flow charts, algorithms or programs with which his best mode would operate.

Applicant's assertions that the absence of details in the specification of how to practice his best mode is overcome since these details are understood by or are obvious to those skilled in the art would have relevancy if the missing portions were merely ancillary to the invention as claimed. Here, the program is the crux of the invention.

Applicant's disclosure is overwhelmingly devoted to an elaborate description of an electro-mechanical analog embodiment. Along with scattered references to a digital computer is a single sentence at page 24 of the specification stating that "the best mode contemplated by the inventor for carrying out the invention is to perform the processing steps of the invention on a large scale digital computer with the processed data printed into visible form on any of the presently available plotting devices".

To achieve applicant's invention a person skilled in the art would have to find digital hardware equipment able to carry out the invention, and make flow charts and write programs which are not necessarily set out in the prior art.

To achieve applicant's objectives would thus require experimentation at length and an inordinate amount of speculation, industry and ingenuity, as the disclosure is merely an invitation to others to see if they can obtain Applicant's objectives which Applicant does not disclose how to obtain.

It is the Examiner's position that to permit Applicant to reap the benefits of the exclusive privilege conferred by a patent grant while withholding from the public the information necessary to best carryout the invention would be inconsistent with the Constitutional purpose of the patent system "To promote the progress of science and useful arts". As stated by the Seventh Circuit Court of Appeals, to permit the patentee "to accept the monopoly and withhold the *full disclosure* of the 'best mode contemplated by the inventor' which will result in a contribution to the common good upon exploration of the monopoly is the 'selfish desire' against which 35 USC 112 is directed". *Flick-Reedy Corp. v. Hydroline Mfg. Co.*, 146 USPQ 694, 697 (1965) (emphasis added).

The affidavits by Miller and Cardwell have been considered and have not been found persuasive.

First, since Cardwell has not written any program for purposes of carrying out the invention, there can be no valid factual data to support his contention that a program for this invention could be written by any person skilled in the art to carry out the invention with only a reasonable amount of experimentation and ingenuity, as the invention requires complex routines, interfacing, and appropriate hardware to be selected and programmed.

Secondly, both affiants merely express opinions in the form of conclusions without facts on which their conclusions are based. Also noted is that Miller fails to specify how long it took him and the three others he worked with to achieve the final working program and at how great an expense.

Furthermore, affiants have not revealed what other information, besides that disclosed in the instant application, was made available to them. There is no basis for presuming that their information was limited to the patent application itself. Exhibits I–II have been considered and are not found convincing in view of the complexity involved in the transition from an analog mode of processing, as set forth in the specification, to a digital mode run on a programmed general purpose computer.

2) Claims 15, 18–23, 25 and 27 are rejected under 35 USC 100 and 101 as directed to a non-statutory class of invention as the claims are directed to an automated digital processing system and method, and the best mode disclosed is a programmed digital computer for carrying out the process. Since initiation and reception of seismic signals, computer operations on seismic signals and sonogramming for seismic records are old in the art, any Patent that would issue on applicant's claims would wholly preempt the algorithm and program for carrying out the invention. This would in practical effect be a patent an the algorithm and program themselves.

Applicant's assertion that the *Benson* decision upholds the patentability of the presently claimed invention fails to take into consideration the *entire* opinion as presented by Mr. Justice Douglas. Although the

Court barred the conclusion that all software is unpatentable *per se*. 409 U.S. at 71, the Court did cite *the Report of the President's commission, see supra,* and several law journal articles and concluded its opinion by admonishing the legislature that "considered action by the Congress is needed." 409 U.S. at 73. Thus, *Benson* has merely stated that some computer process may be patentable without stating any prerequisites for such patentability. The policy basis for the decision, however, precludes patentability where, as in the present application, the invention comprises a program and algorithm utilized in conjunction with a digital computer. The method sought to be patented has as its best mode application by programmed digital computer. This being the case, the instant claims if allowed would wholly preempt the mathematical process as described by applicant in the specification and would in practical effect be a patent on the mathematics, algorithm and program.

Applicant's assertion that claims directed to a particular end use or to a particular apparatus or machinery, would be patentable, is nugatory in view of *Benson* and *Christensen*. In *Benson*, claim eight (8), parts one (1) and seven (7) referred to a reentrant shift register, *a particular apparatus*, and this did not save this claim from being held as directed to an unpatentable invention. In *Christensen*, the factor of a specific end use, e.g., porosity determination of a subsurface formation did not save those claims from being held directed to a non-statutory invention. Thus, the present claims, though drawn to a specific end use, e.g., signal processing of seismic data, and specific apparatus, e.g., a digital computer, are unpatentable as

the invention per se is not within the statutory category of a process.

Although claims 15, 18–23 and 25 are cast in apparatus (means) language (claim 27 is cast in method terms) this is not considered to be of moment as the substance of the invention is what is considered. Casting the language of the claims in apparatus form can not avoid the application of the law as stated in *Benson*.

3) Claim 25 is rejected under 35 USC 112 paragraph two, for being dependent upon cancelled claim 24. This claim thus fails to particularly point out applicant's invention.

4) Applicant's arguments have been considered and not found convincing.

This Action is made *FINAL*.

NELSON MOSKOWITZ
Nelson Moskowitz
Examiner
Group Art Unit 222

APPENDIX E

APPLICATION OF JOHN W.C. SHERWOOD, FILED APRIL 14, 1975, SERIAL NUMBER 567,458, FOR CONTINUOUS AUTOMATIC MIGRATION OF SEISMIC REFLECTION DATA WITH WAVEFORM PRESERVATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, JOHN W.C. SHERWOOD, a citizen of the United Kingdom and a resident of the city of Whittier, County of Los Angeles, State of California, have invented new and useful improvements in

CONTINOUS AUTOMATIC MIGRATION OF SEISMIC REFLECTION DATA WITH WAVEFORM PRESERVATION

of which the following is a specification:

ABSTRACT OF THE DISCLOSURE

Amplitude-versus-time information of a seismic time section is automatically migrated so that events on the time section are displaced, both vertically and horizontally, into positions on a seismic depth section that correspond to actual spatial positions of seismic reflectors in the subsurface. The migration is continuous in the sense that it moves the entire waveforms, not merely previously picked events.

This invention pertains to the art of geophysical prospecting and more particularly to the art of processing seismic data so that representations of significant events in those data may be displayed on a 2-dimensional surface, or in a 3-dimensional model, in locations corresponding to the actual spatial locations of the subsurface reflectors that produced those events.

It is well known in the art of seismic prospecting to display on a 2-dimensional surface the signals received by sets of geophones, the geophone positions being represented by points horizontally extended across the surface and the signals received from the geophones being represented by wiggly lines, (or variable density, or variable area lines) extending vertically from their respective geophone positions. The traces so represented are actually amplitude versus time traces. They do not directly represent subsurface reflectors but, because they are customarily displayed side by side, they do suggest by the apparent visual continuity of some of the recorded events from trace to trace, strata in the subsurface. It is customary to view events that are continuous from trace to trace as representations of the subsurface stratal reflectors, although skilled seismologists are at the same time aware that the reflectors so represented are not properly located spatially.

An array of traces like that described above, consisting of perhaps several hundred traces, is commonly referred to as a "time section" and the true object of the interpretation of the seismic data is to convert the time section into a "depth section" upon which events will actually represent reflectors in their proper spatial positions.

Referring to FIGURE 1 which represents a conventional time section, one can note sets of reinforced wiggles from trace to trace under their respective geophones in which sets of wiggles the same event was evidently received sooner by the left-hand geophone than by the right-hand geophone of the set. It is, of course, known that in such a case the seismic wavelet represented by the event did not come from vertically

below the respective geophones but must have come from some spatial location to the left of the geophones in the subsurface so that a spatially proper representation of that reflection should not be under the respective geophones.

It is even possible for events to appear on the time section in the wrong order with respect to depth. The time section can actually show a reflection from a shallower reflector at a later time than it shows a reflection from a deeper reflector, if the shallower reflector is highly dipping, and the deeper reflector is horizontal.

The most common manifestation of the deficiency of the time section is the one prominently exhibited in FIGURE 1. If one were to think of the more or less horizontally connected events in FIGURE 1 as representing subsurface strata, then, in the right-hand lower part of the section, one would be confronted with the naturally impossible interleaving of two sets of strata. Sedimentary beds are, of course, not deposited in this way. The sets of apparently interleaving events are known to seismologists as "multiple time branches" and skilled seismologists know how, by hand calculations on selected events of the record, to "migrate" those selected events to spatially proper places on a depth section so that the phenomenon of multiple branches interleaving at an angle does not occur on the final depth section. But heretofore there has been no method to convert the entire ensemble of data on the time section into a spatially proper, corresponding ensemble of data on a depth section.

Another deficiency of the conventional time section, not as often apparent as the phenomenon of multiple

time branches, is that the conventional time section by its very nature cannot show an abrupt horizontal discontinuity such as the abrupt ending of a stratum that has been cut off by a fault, or the abrupt beginning, at another higher, or lower, position, of the former continuation of that cut-off stratum. It can be shown theoretically that the conventional time section can show only an indefinite diffraction image of such an abrupt discontinuity. One of the oustanding advantages of the method to be described in the present invention is that it produces out of the indefinite diffraction representations of faults in conventional time sections, remarkably definite spatial representations of faulted ends of strata.

* * * * *

Another prior patent pertinent to this invention is that of R. Lara, U.S. 3,346,840, October 10, 1967 for "Double Sonogramming for Seismic Record Improvement", assigned to the assignee of the present invention. That patent teaches the use of the double sonogram, or inverse sonogram. Among seismologists, the sonogram itself is familiar as a set of parallel amplitude-versus-time traces, the individual traces representing individual directions into the earth, rather than individual geophones, or geophone groups, as do the traces of a conventional seismic record. Lara showed how the sonogram itself may be sonogrammed again (double sonogrammed, or inverse-sonogrammed) to produce a final set of parallel, amplitude-versus-time traces, the individual traces again representing individual locations rather than directions. In a preferred embodiment of the present invention, the principle of the double sonogramming operation is ex-

tended to the use of sonogram traces built up of segments from various parts of a seismic time section. Indeed, it is these sonogram trace segments that are literally migrated, rather than trace segments of the original record.

The preferred embodiment of the present invention comprises sonogramming conventional seismic traces from sets of geophones, or sets of geophone groups, to produce sonogram traces in which the amplitude-versus-time information is sorted so as to indicate the direction of arrival of its various components. Then, with the aid of a determined (or an assumed) seismic velocity function, segments of the sonogram traces are migrated, both horizontally and vertically, into locations on an intermediate record, corresponding to the horizontal positions, and the depths, of reflectors that could have produced those segments. The information on the intermediate record, or intermediate sonogram section, is in the form of many small sonograms that are unlike prior art sonograms in the sense that their side-by-side traces did not come from side-by-side geophones, or geophone groups, but from possibly widely-spaced locations over the original seismic time section. Finally, the many small sonograms are sonogrammed again (double-sonogrammed, or inverse-sonogrammed) to produce new amplitude-versus-depth traces, among which successive vertical traces represent again successive horizontal subsurface positions, and events on those traces represent seismic reflectors in the subsurface in positions corresponding to their actual positions.

In a preferred form of the present invention, advance calculations are made with the aid of a determined (or assumed, or otherwise preselected) seismic

velocity function to designate precisely which small portions of the original record are to be sonogrammed to produce the sonogram trace segments that will migrate to each small zone, or zonelet, of the intermediate sonogram section, and final seismic depth section.

* * * * *

Now, the fundamental problem solved by the present invention is to gather data from everywhere on the time section and relate them back to the subsurface locations of their origin. If time sections contained only a few simple data as shown in FIGURE 3 the solution would be easy and obvious. The reflection RA shows a definite "moveout"; i.e., among the geophones in the neighborhood of point a, the left-hand geophone received the signal before the right-hand geophones. Obviously then, the reflection came from below and to the left at an angle indicated by the moveout angle and at a distance equal to half the time of receipt on the time section multiplied by the seismic velocity. Similar reasoning would apply to reflections RB, RC and RD.

As simple as is the FIGURE 3 example, it indicates the fundamental mathematical difficulty of the migration of seismic records. The migration process is not just a "mapping" process in which each point on the time section corresponds to a point on the depth section, so that a wiggle appearing at a time section point just needs to be transferred to its corresponding depth section point. In the migration process, a wiggle appearing at a point on the time section may need to be transferred leftward or rightward depending on what direction is indicated by the kind of reinforcement which that wiggle receives from wiggles on neighbor-

ing traces. More precisely, each wiggle must be separated into a number of components, according to the various reinforcements it receives from its neighbors, and these components must be transferred to various, perhaps widely spaced, locations.

I have found that the migration process may be carried out, using presently available apparatus of reasonable complexity, and using presently available apparatus of reasonable complexity, and using presently available recording materials (either magnetic tapes or photographic films), if the migration is performed in two overall steps as follows: The original data are scanned at various preselected moveouts, and the results of the scannings are stored on an intermediate sonogram section that is divided into zonelets, each zonelet as a whole having a horizontal coordinate and a vertical coordinate referring to its center point. Within each zonelet of the intermediate sonogram section the amplitude information is in the form of vertical traces representing amplitude versus depth; but there the similarity to conventional seismic records stops. Within each individual zonelet the neighboring traces from left to right do not represent different horizontal positions; they are all associated with the same horizontal position, the position of the center of the zonelet. The different traces from left to right within an individual zonelet represent different stratal dip angles on both the intermediate sonogram section and the final seismic depth section.

The collection of traces, from left to right within an individual zonelet, constitutes a small sonogram, but as mentioned hereinbefore, it is a sonogram unlike prior art sonograms in the sense that its side-by-side traces did not come from side-by-side geophones, or

geophone groups, but from possibly widely spaced locations over the original seismic time section.

In the second overall step, the individual zonelets are themselves sonogrammed, and for each individual zonelet a final set of traces is produced, which now do represent successive horizontal positions by their successive horizontal order.

In the finally produced seismic depth section all vertical traces represent amplitude-versus-depth information, and the horizontal distances between traces represent actual horizontal distances, so that all amplitudes may now be properly said to be functions of just two coordinates, the horizontal displacement and the depth.

In the process as described so far the sonogram has been mentioned several times, and reference has been made to the Lara patent, U.S. 3,346,840, which discloses and explains double sonogramming or inverse sonogramming. Whereas the Lara patent should serve as a basic reference for the understanding of the present invention, the steps of double sonogramming, or inverse sonogramming, as explained in that patent, are disclosed as being performed on a sonogram consisting of traces all of which came from a set of neighboring traces. The final result of the Laura double sonogramming is a set of traces containing the same basic information as that original set of neighboring traces, but in the processed traces the meaningful information has been emphasized and the meaningless information (the noise) has been deemphasized. In the present invention, the sonogram is used in a different, and more advanced way. The sonogram traces from an original set of neighboring

traces are not kept together. Instead the traces indicating receipt of seismic waves from, say, a leftward direction are moved to leftward locations, and the traces indicating receipt of seismic waves from a rightward direction are moved to rightward locations. The traces that become neighboring traces on the intermediate sonogram section have not necessarily been derived from neighboring original seismic traces.

Sonogramming is here used for separating information according to its arrival directions, and then transferring the separate parts to sometimes widely separated parts of an intermediate sonogram section. The transferred sonogram trace segments act as compact information storage devices. Information gathered from several (or many) traces is stored in one trace segment which is transferred to a new location, and in that location the transferred segment stores information that the second sonogramming operation will spread out over several (or many) neighboring traces.

* * * * *

At this point it may be appreciated that the compaction associated with sonogramming makes possible the solution of the information storage problem mentioned in an early part of this specification. It becomes unnecessary to plot traces on top of each other as in the prior art, and it therefore becomes unnecessary to find magnetic or photographic information storage media which have responses that remain linear, independently of the number of times those media are reused.

In the example schematized in FIGURE 4, a complete set of traces could have been shown in the intermediate sonogram section zonelet, but in the simplified

case intended to be represented here, the other traces would be "blank"—that is, they would show no wavelets that would indicate other seismic reflectors crossing the reflector there represented. In actual practice all traces of all zonelets may be recorded, and each of them may contain at least some "noise" which manifests itself as false reflector segments superimposed on whatever true reflector segment is properly indicated. The practical usefulness of the process, of course, depends on the existence of a high enough signal-to-noise ratio to make the true reflector segment dominate the display. In any case, it will be appreciated that the migration process, tending as it does to separate superimposed information from various directions, must, in all but the most exceptional circumstances, greatly increase the effective apparent signal-to-noise ratio of the seismic record section. This is well indicated in the actual case examples shown here as FIGURES 1, 2, 7 and 8.

There are other known ways to increase the effective apparent signal-to-noise ratio of a seismic record section. Various kinds of nonlinear amplification, and "picking", or both may be applied to seismic data, and these may be applied during one or more of the stages of the method of the present invention to enhance the final record. Example methods of enhancement are mentioned in the previously cited Lara patent, U.S. 3,346,840, and more extensive descriptions are found in two other patents, U.S. 3,149,302, Klein et al, "Information Selection Programmer Employing Relative Amplitude, Absolute Amplitude and Line Coherence," and U.S. 3,273,114, Stephenson et al, "Ergodic Signal Picking", all assigned to the assignee of the present invention.

FIGURE 5 illustrates an analog form of apparatus for carrying out the method of the present invention. The analog form has here been shown because it is more readily comprehendable in terms of its ability to perform the steps of the method of this invention. However, it will become evident that the method can also be, and in most cases will be, performed employing a large storage capacity, high speed computer between the field tapes and the final seismic section.

* * * * *

The procedure of sonogramming is well known in the seismic art; it constitutes the production of a plurality of amplitude-versus-time traces of the sum of the instantaneous signal amplitudes of adjacent traces of a profile of a seismic time section, each trace being a summation with differential time shifts between the traces of the profile section. The summation traces are recorded as representing the directional plane wave components in the profile of the seismic time section at the moveout corresponding to the pivot angle of the pivotally mounted head moving bar 18. The sonogramming procedure transforms the profile of the seismic time section from a plurality of amplitude-versus-time traces having different horizontal coordinates into a plurality of amplitude-versus-time traces having different moveouts.

Consider now a sonogram trace being plotted on drum 21. The trace will begin at (or approximately at) zero depth and proceed toward the total depth, corresponding to the major part of a revolution of drum 21. The entire single sonogram trace will represent data for a fixed dip angle Θ in the x-z plane, and the entire single trace will be at a constant horizontal coordinate,

x, (a constant axial coordinate) on the drum 21. However, for the data to represent a constant dip angle, and to be plotted at a constant horizontal coordinate in the intermediate sonogram section, with only the depth z varying, they cannot come from locations in the time section all having the same horizontal coordinate, or even having the same moveout angle. Qualitatively, it is obvious that if the sonogram trace being plotted represents reflectors dipping to the left, then as the depth z increases, the horizontal coordinate at which corresponding signals were received on the time section must move leftward. It is also evident that with velocity variation of the usual sort, increasing monotonically with depth, the moveout angle at which corresponding signals were received on the time section must decrease as the depth z increases; when the reflector dip angle is held constant. Even the simplest relationship, the one between the time t and the depth z, which quantities are represented by the rotational angles of drums 11 and 21 respectively, is not a simple proportionality in the variable velocity case. It is this relationship which will here be dealt with first.

From familiar fundamental equations of geophysics, it is not difficult to show that, if the seismic velocity variation with depth is represented by a function of depth, v(z), then the two-way travel time $t(z_i)$ for a reflector at dept z_i, having a dip angle, $\Theta(z_i)$, is:

$$t(z_i) = \int_0^{z_i} \frac{2dz}{v(z)\sqrt{1-[v(z)/v(z_i)]^2 \sin^2\Theta(z_i)}}$$

Inspection of the above equation shows that instead of $t(z_i)$ being directly proportional to z_i it is less than

proportional, or the coefficient of proportionality decreases with increasing z_i no matter what the dip angle may be (although the greater the dip angle, the less the coefficient decreases). Apparatus to take into account this relationship is incorporated into the apparatus of FIGURE 5 as follows:

* * * * *

Now, the relation between the rotational motion of drum 21 and the axial motion of head positioner 16 will be described. The controlling mathematical expression is somewhat similar to the previous one for two-way-travel-time versus depth. The horizontal migration distance, which is the difference, Δx, between the x-coordinate of the geophones receiving a reflection, and the x-coordinate of the corresponding reflector at depth z_i and dip angle Θ is:

$$\Delta x = \sin \Theta \int_0^{z_i} \frac{v(z)\, dz}{v(z_i)\ \sqrt{1-[v(z)/v(z_i)]^2 \sin^2 \Theta}}$$

The sin Θ quantity in front of this expression of course causes the horizontal migration to be plus or minus, rightward or leftward, in accordance with the sign of the dip. Apparatus to take into account the above relationship is incorporated into the apparatus of FIGURE 5 as follows:

* * * * *

The last functional relationship that needs description here is the one controlling the movement angle, the rotational angle of the head moving bar 18 about the axis of shaft 17. (That axis corresponds to the

sonogram pivot point during the sonogramming of record 12.)

It is not difficult to show that, if the seismic velocity variation with depth is represented by a function of depth, v(z), then the moveout m of the emergent reflection from a reflector at depth z, having a dip angle $\Theta(z)$ is:

$$m(z) = \frac{dt}{dx} = \frac{2 \sin \Theta(z)}{v(z)}$$

If the rotational angle of pivot axis 17 is denoted by $\alpha(z)$, then it follows, from simple geometry, that the moveout sonogrammed by heads 15a, 15b and 15c is given by:

$$m(z) = \frac{dt}{dx} = K_{12} \tan \alpha(z)$$

where k_{12} = a constant of proportionality between t and x on recording medium 12.

Then:

$$\alpha(z) = \arctan \left| \frac{m(z)}{k_{12}} \right|$$

$$= \arctan \frac{2 \sin \Theta(z)}{k_{12}\, v(z)}$$

This relationship is incorporated into the apparatus of FIGURE 5 as follows:

Cams 95a, 95b, and 95c, mounted on shaft 102, are cut so that their radii, $r_m(z)$, are given by:

$$r_m(z) = 1 - k_m \alpha(z)$$

where k_m = constant of proportionality between cam radius and pivot axis 17 rotational angle.

Cam 95a is for a negative Θ, cam 95b is for $\Theta = 0$ and cam 95c for a positive Θ. Consider the case of sonogramming to find reflectors of a negative dip angle Θ. As drum 21 is turned by motor 23, shaft 60 turns pulley 93, which turns pulley 94, and in turn cam 95a, whose varying radius is sensed by follower 96, which through bar 97 and cable 103 and reel 98 transmits a rotation to position repeating motor 99. Motor 99 is connected through leads 100 to its mate 101, which rotates shaft 17 at head position 16. Thereby, the move-out at which record 12 is being sonogrammed changes in accordance with the cam contour that was produced in accordance with the above given equation.

* * * * *

The visible results of the described method constitute more than an incremental improvement over results of the prior art. The difference is sometimes so great that meaningful comparisons are impossible. FIGURES 7 and 8 are intended to illustrate this point. In FIGURE 8, which is reproduced from an actual final seismic depth section prepared by this method, a fault is clearly visible above and to the left of the center of the section. One pair of strata shows a clear termination, a vertical shift, then a resumption. It would have been impossible to produce this fault image by the methods of prior art that involved migration of small "picked" portions of the time section. This is because the diffraction image of the fault, in the time section, FIGURE 7, is too indefinite to be pickable by state-of-the-art methods. FIGURES 7 and 8 are therefore believed to provide both a clear indication of

the novelty and a clear illustration of the power of the above-described invention.

The final seismic depth section reproduced in FIGURE 8 was actually prepared by performing the method of the present invention on a large scale digital computer. It should be understood that the analog apparatus here shown as mechanical devices electrically interconnected are intended to assist in the understanding of the invention. The best mode contemplated by the inventor of carrying out the invention is to perform the process steps of the invention on a large scale digital computer with the processed data imprinted into visible form on any of the presently available plotting devices.

While certain preferred embodiments of the invention have been specifically disclosed, it should be understood that the invention is not limited thereto as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims:

WHAT IS CLAIMED IS:

* * * * *

REJECTED CLAIMS

15. A system for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a seismic depth section consisting of a plurality of amplitude-versus-depth traces, so that events on the time section are migrated, both vertically and horizontally, into positions on said depth section corresponding to the actual spatial positions of the seismic reflectors in the subsurface, comprising:

(a) automated data processing means for sonogramming said amplitude-versus-time traces, a group of traces at a time, to produce a plurality of sonograms each identified, indexed and stored with a respective horizontal pivot coordinate of a respective group of sonogrammed amplitude-versus-time traces, and with a represented moveout,

(b) machine means for dividing each individual sonogram into a series of segments in accordance with a pre-selected seismic velocity function, and reindexing and storing, also in accordance with said preselected velocity function, each of said series of segments into a particular storage zonelet representing a portion of said seismic depth section identified and indexed by a particular depth and horizontal coordinate, each of said series of divided and stored segments also being identified and indexed within a particular zonelet in accordance with a represented dip angle,

(c) machine means for automatically sonogramming said segments divided and stored within each of the zonelets to produce a final plurality of amplitude-versus-depth representations and

(d) machine means for directing and plotting the placement of said final representations on said seismic depth section, so that said seismic reflectors in said subsurface can be identified, in the vertical and horizontal location, by amplitude variations on said amplitude-versus-depth traces of said depth section.

18. System for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a seismic depth section consisting of a plurality of amplitude-versus-depth traces, so that events on the time section are migrated, both verti-

cally and horizontally, into positions on said depth section corresponding to the actual spatial positions of the seismic reflectors in the subsurface, comprising:

(a) automated data processing means for sonogramming said amplitude-versus-time traces, a group of traces at a time, to produce a plurality of sonograms, each identified by a respective horizontal pivot coordinate of said original group and by a represented moveout,

(b) automated data processing means for dividing said each individual sonogram into segments in accordance with a preselected seismic velocity function, and indexing and storing, also in accordance with said preselected seismic velocity function, said segments into zonelets each of which representing, depthwise, a portion of said seismic depth section and identified by particular depth and horizontal coordinates,

(c) machine means for sonogramming in each of said zonelets said divided and stored segments to produce final amplitude-versus-depth segments, and plotting said final amplitude-versus-depth segments within final zonelets of said seismic depth section, said final zonelets of said depth section having boundaries, depthwise, corresponding to those of the respective zonelets of said machine divided and stored segments of (b).

19. The system of Claim 18 wherein said machine divided, indexed and stored segments of (b) are ordered, as to position, within said zonelets according to their represented dip angles.

20. In a system for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a seismic depth section consisting

of a plurality of amplitude-versus-depth traces where events on the time section are migrated, both vertically and horizontally, into positions on said depth section corresponding to the actual spatial positions of the seismic reflectors in the subsurface, and reflectors in the depth section are represented by amplitude variations on adjacent side-by-side traces, with each trace extending from a surface location in a direction representing vertical distance below said surface position, an improvement comprising:

(a) for each zonelet representing a portion of said seismic depth section, automated machine means for generating a plurality of discrete, individual segments from individual sonograms of said seismic time sections, said automated means dividing said individual sonograms in accordance with a preselected seismic velocity function and then migrating, vertically and horizontally, them to said zonelets in accordance with said preselected seismic velocity function, said zonelets being identified by their depths and horizontal coordinates, each of said divided and migrated segments being ordered as to positions within each of said zonelets in accordance with its represented dip angle,

(b) automated machine means for generating another series of sonograms of said divided and migrated segments to produce said final amplitude-versus-depth traces, and

(c) machine means for plotting said final traces as said side-by-side traces of said seismic depth section whereby seismic reflectors in said subsurface can be identified, in the vertical and horizontal location, by amplitude variations on said amplitude-versus-depth traces of said depth section.

21. An apparatus for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a plurality of machine generated, amplitude-versus-depth representations, so that events on the time section are migrated, both vertically and horizontally, according to the depth and horizontal coordinates of the seismic reflectors within a subsurface earth formation, they represent, comprising:

(a) automated data processing means for sonogramming said amplitude-versus-time traces, a group of traces at at time, to produce a plurality of sonograms each identified by and indexed through a respective horizontal pivot coordinate and a represented move-out,

(b) automated means for machine dividing each of said individual sonograms into a series of segments in accordance with a seismic velocity function characteristic of the subsurface under study, and for each of a series of zonelets representing portions of said subsurface under study, said automated dividing means including separate means for placing, storing and indexing also in accordance with said seismic velocity function, said series of segments into said zonelets to provide said plurality of machine generated, amplitude-versus-depth representations.

22. A system for converting a seismic time section consisting of a plurality of amplitude-versus-time seismic traces, into a seismic depth section consisting of a plurality of amplitude-versus-depth traces, so that events on the time section are migrated, both vertically and horizontally, into positions of said depth section corresponding to the actual spatial positions of the seismic reflectors in the subsurface, comprising:

(a) automated machine means for sonogramming said amplitude-versus-time traces, a group of traces at a time, to produce a series of sonograms each identified by and indexed as a function of a respective horizontal pivot coordinate and of a represented moveout,

(b) automated machine means for rearranging individual, seismically continuous segments of each of said sonograms whereby said segments are ordered as to stored positions, their horizontal coordinates representing the horizontal coordinate and dip angle of subsurface reflector segments,

(c) automated machine means for sonogramming said machine rearranged segments to produce final amplitude-versus-depth traces, and

(d) machine means placing and re-indexing said final traces within said seismic depth section within boundaries corresponding to those of (b) from which said final traces were produced.

23. A system for converting a sesimic time section consisting of a plurality of amplitude-versus-time seismic traces, into a sonogram section consisting of a plurality of amplitude-versus-depth traces, so that events on the time section are migrated, both vertically and horizontally, into positions on said sonograms section according to the depth and horizontal coordinates of the seismic reflectors they represent, comprising:

(a) automated machine means for sonogramming said amplitude-versus-time traces, a group of traces at a time, to produce a series of sonogram traces, each sonogram trace being identified by and indexed through a respective horizontal pivot coordinate and a represented moveout,

(b) automated machine means for mathematically dividing each of said individual sonogram traces into a plurality of segments in accordance with a seismic velocity function characteristic of the subsurface under study, and

(c) automated machine means for directing the placing of and re-indexing of said segments in zonelets also in accordance with said seismic velocity function whereby seismic reflectors in the subsurface under study can be identified, in true vertical and horizontal locations.

27. A method for converting a seismic time section comprising a plurality of amplitude-versus-time seismic traces, into a seismic depth section comprising a plurality of amplitude-versus-depth traces, to that amplitudes representing events on the time section are migrated, both vertically and horizontally, into positions on said depth section corresponding to the actual spacial positions of the seismic reflectors in the subsurface, comprising the steps of:

(a) by operation of automated data processing means, beam steering without substantially changing signal waveform, said amplitude-versus-time traces, a group of traces at a time, to produce a plurality of directional traces, each directional trace being identifiable by being its horizontal pivot point coordinate relative to said original group of amplitude-versus-time traces and by a beam steer angle selected from a given range of beam steer angles,

(b) machine associating in accordance with a preselected seismic velocity function, each of a series of individual segments of each directional trace, with one of a plurality of zonelets representing a portion of said

seismic depth section, each associated segment being identified by particular depth and horizontal coordinates of said one zonelet and its position in said zonelet,

(c) by operation of automated data processing means, again beam steering the collection of waveform-preserved trace segments associated with each of the zonelets over a plurality of beam steering angles corresponding to preselected dip angles of reflectors in said portion of said depth section, depth segments within final zonelets of said seismic depth section, said final zonelets of said depth section having boundaries corresponding to those of the respective zonelets of said machine divided and placed segments of step b.

☆U.S. GOVERNMENT PRINTING OFFICE 1980 321376 1